Monitoring the State of the ST. LAWRENCE RIVER

Sediment quality status of Lake Saint-Pierre in 2013

Highlight: Sediment quality in the northern part of Lake Saint-Pierre is considered good in terms of the concentrations of a number of contaminants. Sediments from the area of the Berthier-Sorel Islands continue to be of concern, particularly due to the presence of emerging contaminants such as polybrominated diphenyl ethers (PBDEs).

Issue

Since the 1900s, the water and sediments of the St. Lawrence River have been contaminated by many different toxic substances (metals, PAHs, PCBs) from industrial, agricultural and urban sources. With the implementation of pollution remediation measures in the 1980s, sediment contaminant concentrations have declined considerably and today are below the threshold concentrations that can have effects on aquatic organisms (EC and MDDEP 2007).

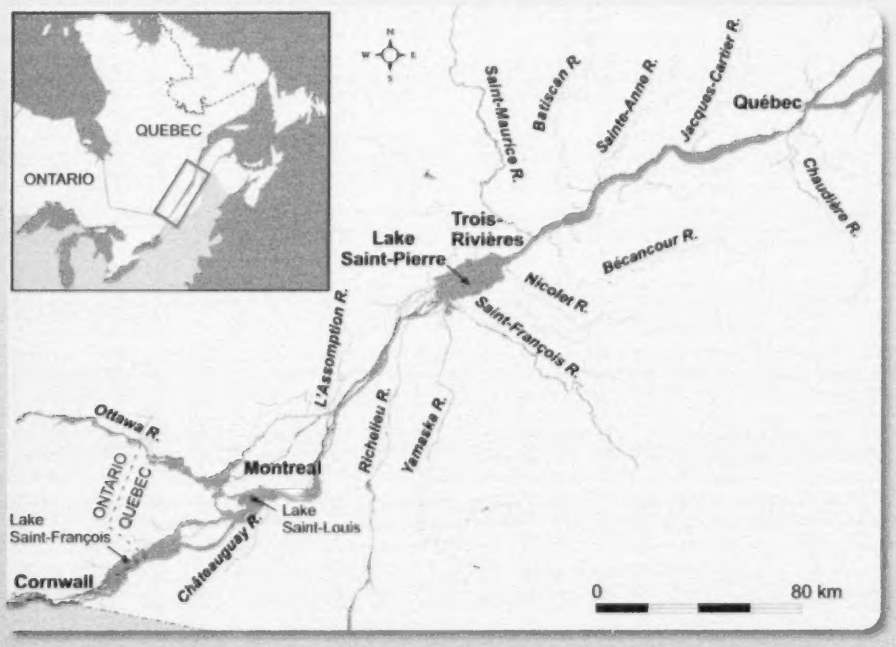

Figure 1. Fluvial sector of the St. Lawrence River including Lake Saint-Pierre where sediment sampling occurred in 2013

At the turn of the 21st century, the development of new technologies resulted in the use of a number of organic contaminants, such as PBDEs, coming from urban wastewater. Little is known about their harmful effects on aquatic fauna, and the development of quality criteria is still at an early stage.

The results of current and past characterizations were analyzed in order to assess the quality of Lake Saint-Pierre sediments and identify emerging trends. Since the 1970s, surface sediments in Lake Saint-Pierre have been sampled four times:

- The first study, which was carried out in 1976, primarily in the upstream part of the lake, namely the area around the Berthier-Sorel Islands, focused largely on metal contamination of sediment (Sérodes 1978).
- The work done in 1986 produced an initial status report on a number of organic substances in sediment, including polychlorinated biphenyls (PCBs), in most of the northern part of the shipping channel (Hardy 1990).
- Lastly, sediments in the entire northern part of the lake were sampled in 2003 and 2013 by Environment Canada and analyzed for PCBs, chlorinated dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), PBDEs and metals, including mercury. This fact sheet focuses on those recent results.

Key measures

Sediment quality criteria and indices

The *sediment quality criteria* used in this document (TEL: threshold effect level; OEL: occasional effect level) are taken from EC and MDDEP (2007). They are defined on the basis of observed biological effects on benthic and pelagic organisms and contaminant concentrations measured in sediment.

The *quality indices* are calculated by dividing the measured concentration of each substance in each sample by the TEL quality criterion for the substance in question. An index higher than 1 indicates that the concentration exceeds the criterion and biological effects may be observed, whereas an index lower than 1 indicates that sediment quality is good.

Mean quality indices were calculated for metals (except mercury) and PAHs:

The *metals index* is the average of the quality indices calculated for the respective concentrations and criteria for the following seven metals: copper, zinc, lead, nickel, chromium, arsenic and cadmium. The OEL is used for nickel because there is no defined TEL.

The *PAH index* is the average of the indices calculated for the respective concentrations and criteria for the following 12 substances: acenaphthylene, acenaphthene, anthracene, benzo[a]anthracene, benzo[a]pyrene, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene.

The *overall indicator status* is based on the proportion of uncontaminated sites and contaminated sites relative to the total number of sites characterized. This proportion defines an overall status that ranges from good to poor.

Toxic contaminants in the 20th century

Status in 2013: The overall sediment quality status of Lake Saint-Pierre is classified as good in 2013. The concentrations of metals and mercury are below the TEL criterion in almost every case, which indicates very good sediment quality. For PCBs, PAHs and chlorinated dioxins and furans, a number of sampling sites, particularly in the area of the Berthier-Sorel Islands, show concentrations higher than the TEL. However, for the lake as a whole the mean concentrations of these substances are below the TEL (Table 1).

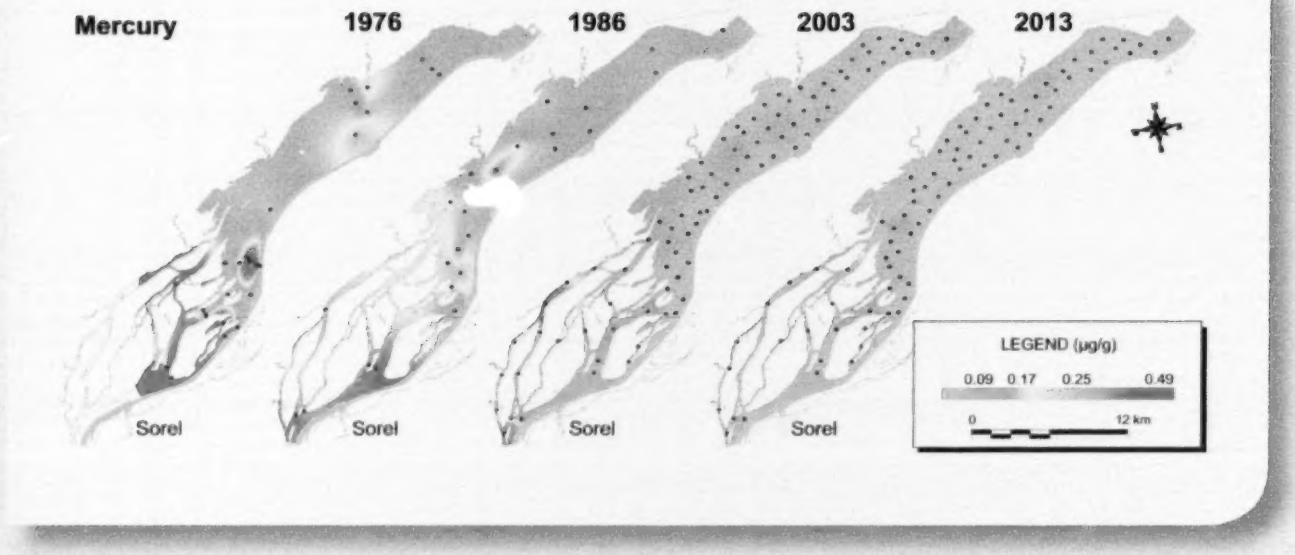

Figure 2. Change in mercury concentrations in Lake Saint-Pierre surface sediments in 1976, 1986, 2003 and 2013

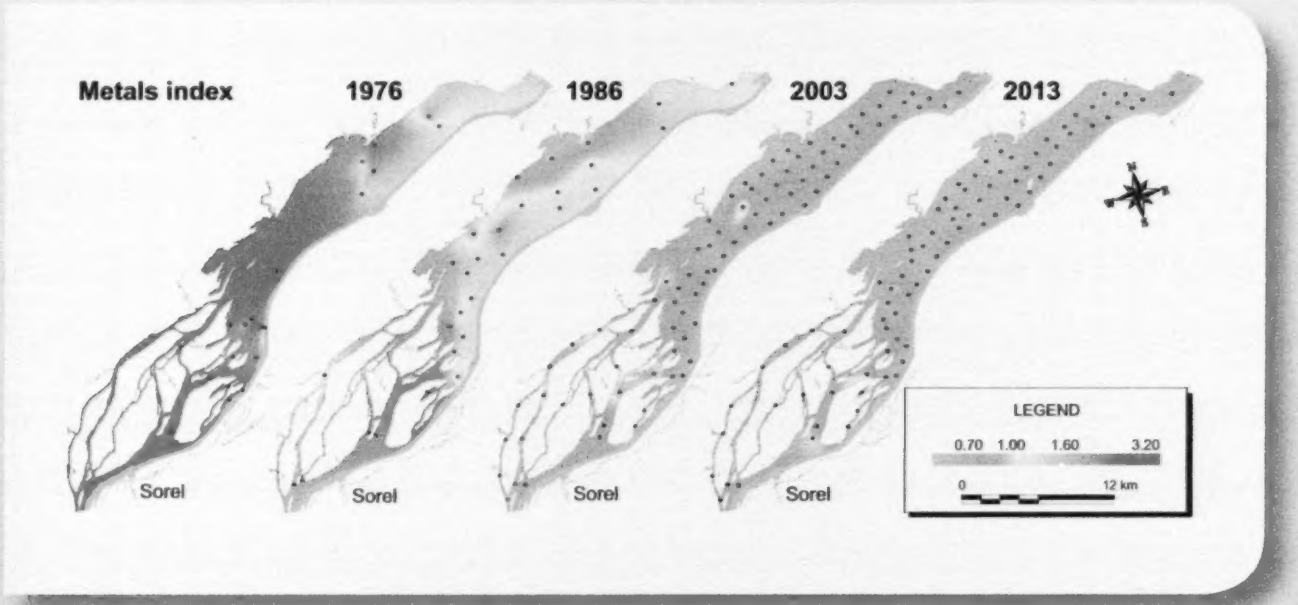

Figure 3. Change in the metals index in Lake Saint-Pierre surface sediments in 1976, 1986, 2003 and 2013

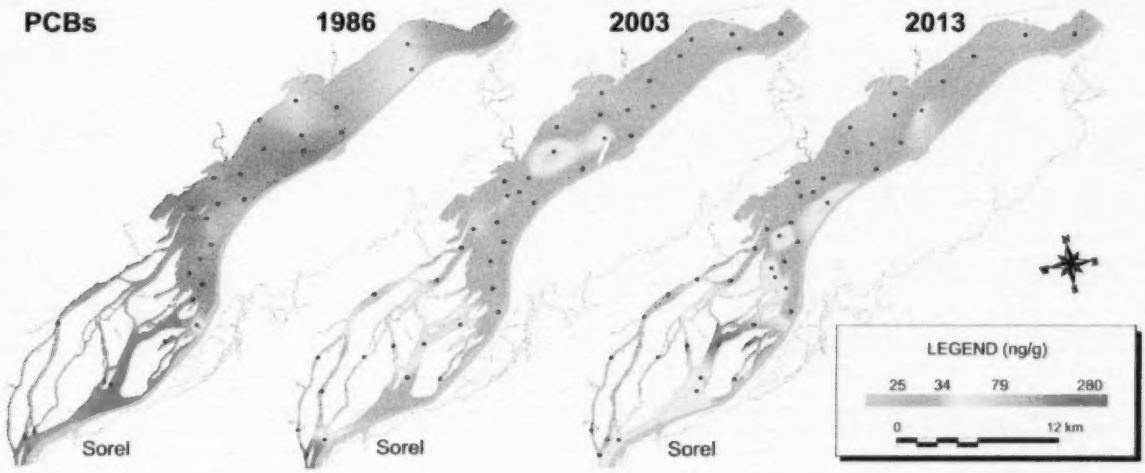

Figure 4. Change in PCB concentrations in Lake Saint-Pierre surface sediments in 1986, 2003 and 2013

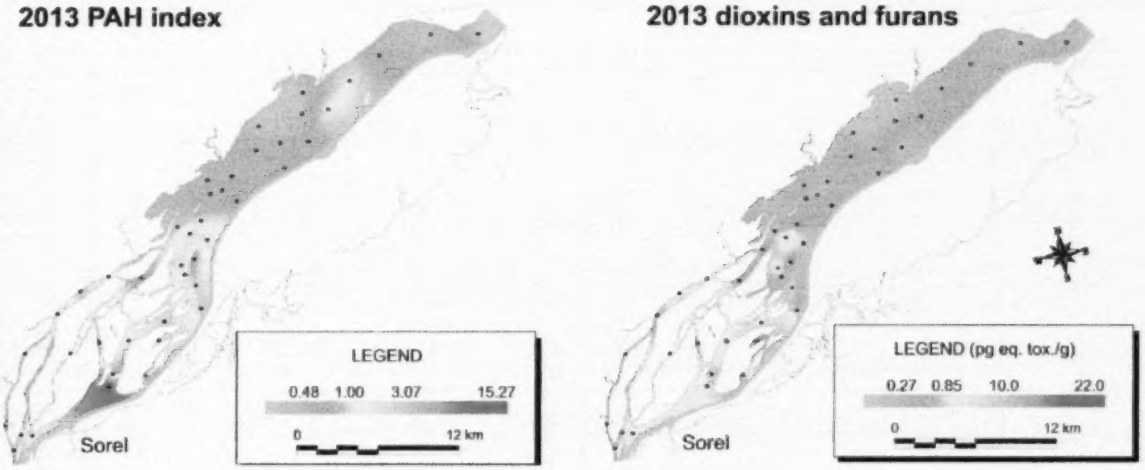

Figure 5. PAH index and dioxin and furan concentrations in Lake Saint-Pierre surface sediments in 2013

MEASURED SUBSTANCES	QUALITY CRITERIA[1]	YEAR OF SAMPLING				VARIATION OF THE AVERAGES	
		1976 [2]	1986 [3]	2003 [4]	2013	Between 2003 and 2013 (%)	Between 1986 and 2013 (%)
Metal Index	1	2.53	1.28	0.42	0.31	25.4	75.5
Arsenic (µg/g)	5.9		2.25	2.03	1.74	14.6	22.9
Cadmium (µg/g)	0.60	5.36	1.02	0.19	0.15	20.7	85.4
Chromium (µg/g)	37	66.13	103.75	23.12	17.47	24.4	83.2
Copper (µg/g)	36	34.54	36.59	16.29	10.55	35.3	71.2
Lead (µg/g)	35	13.61	28.45	7.87	5.65	28.2	80.1
Nickel (µg/g)	47	26.28	32.85	16.15	12.61	21.9	61.6
Zinc (µg/g)	120	121.29	134.96	61.44	46.69	24.0	65.4
Mercury (µg/g)	0.17	0.111	0.111	0.035	0.026	23.6	76.1
Polychlorinated Biphenyls (PCBs)							
Homologous (ng/g)	34		97.50	17.83	17.58	1.4	82.0
Congeners (ng/g)				12.77	10.68	16.4	
Polybrominated diphenyl ethers (PBDEs)							
PentaBDE (ng/g)	0.4			0.87	0.36	58.7	
Polycyclic Aromatic Hydrocarbons (PAHs) Index	1				0.53		
Dioxins and furans (pg éq. tox./g)	0.85				0.22		

(1) EC and MDDEP, 2007; (2) Serodes, 1978; (3) Hardy et al., 1990; (4) Pelletier, 2008

Table 1. Average concentrations and variation of toxic substances measured in sediment of Lake Saint-Pierre between 1986 and 2013

Changes since the 1980s: 1986 was used as a reference year for calculating the percentage change in contaminant concentrations in sediment, since the highest levels of most substances were recorded that year (Table 1).

The mean concentrations of metals (including mercury) and PCBs declined by about 75% and 82% respectively between 1986 and 2013. This decline appears to be continuing since concentrations decreased by 15% to 25% between 2003 and 2013. A comparison of sampling years is not possible for dioxins and furans and for PAHs because these substances were not analyzed. However, it appears that the mean concentrations of dioxins and furans and PAHs in the sediment samples collected in 2013 were below the TEL except in the area of the Berthier-Sorel Islands which remains contaminated.

Contaminants of emerging concern: PBDEs

PBDEs are a group of 209 brominated organic compounds which are used as flame retardants in plastics. Once they enter the aquatic environment, they are persistent and bind to sediment particles. The most harmful PBDEs are those with five bromine atoms (pentaBDEs); BDE-99 and BDE-100 are among those commonly monitored. It should be noted that these contaminants are excluded from the calculation of the overall indicator status.

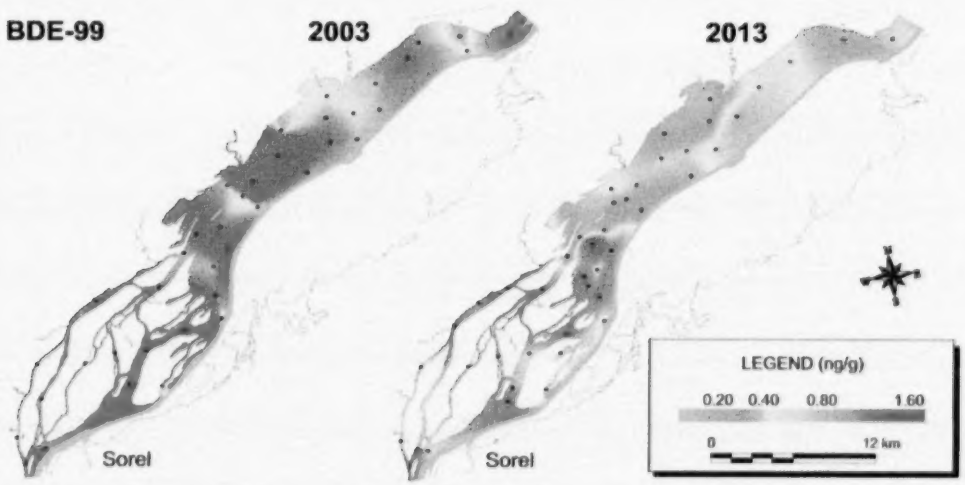

Figure 6. Change in BDE-99 concentrations in Lake Saint-Pierre sediments in 2003 and 2013

Status in 2013: The guideline value of 0.4 ng/g of BDE-99 established by the federal government for the protection of aquatic wildlife (EC, 2011) was exceeded by 42% of surface sediment samples collected in 2013 in the northern part of Lake Saint-Pierre. Nearly half of these samples contained concentrations that were two times higher than the guideline (Figure 6). The highest concentrations were found in the area of the Berthier-Sorel Islands.

Changes since 2003: The mean concentration of pentaBDEs in Lake Saint-Pierre surface sediments declined by 59% between 2003 and 2013 and a marked decrease of 75% was observed in the area of the Berthier-Sorel Islands (Table 1). Despite this decline, close to 60% of the highest concentrations were found in the channels around those islands.

The temporal profiles (Figure 7) show a peak in the concentrations of two pentaBDEs (BDE-99, BDE-100) and of decaBDE (BDE-209) measured in 2006 and 2008. At that time, there was an increase in the manufacture and use of PBDEs immediately preceding the adoption of regulatory measures respecting these substances. The first set of regulations aimed at prohibiting the manufacture of these substances and restricting their use was adopted by the federal government in 2008 (Prohibition of Certain Toxic Substances Regulations [2012]).

Since 2010, the BDE-99 concentration has hovered around the federal guideline of 0.4 ng/g and the BDE-100 concentration has remained below the guideline. The BDE-209 concentration has remained well below the guideline of 18.9 ng/g. These results suggest that PBDE concentrations should continue to decline but that monitoring remains critical.

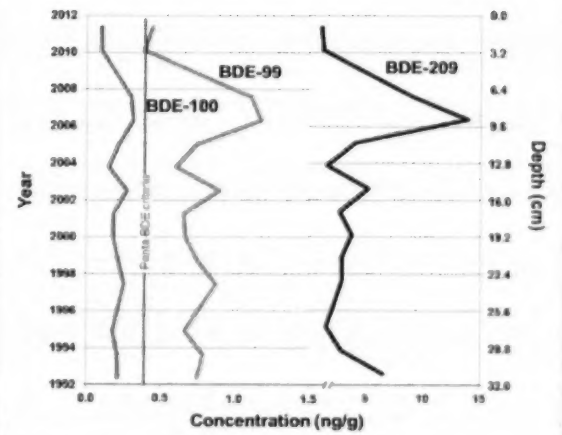

Figure 7. Temporal profiles of BDE-99, BDE-100 and BDE-209 concentrations in Lake Saint-Pierre sediments

Conclusion

Toxic substances such as PCBs, mercury and other metals, PAHs and dioxins and furans in Lake Saint-Pierre surface sediments—a legacy of the industrial expansion of the mid-1900s—have declined significantly to levels below the sediment quality guidelines for the protection of aquatic life. Substances of emerging concern such as PBDEs which are associated with recent uses continue to be monitored despite the decline in their concentrations since 2006.

The entire northern part of Lake Saint-Pierre can be considered relatively unaffected by legacy toxic contaminants with the exception of the area of the Berthier-Sorel Islands. Emerging contaminants such as PBDEs (BDE-99) will continue to be monitored for some time to identify long-term trends. The development of analysis techniques for the detection of organic substances of emerging concern will help provide a more complete picture of sediment quality in the future.

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State of the St. Lawrence Monitoring Program

Five government partners - Environment and Climate Change Canada, Fisheries and Oceans Canada, Parks Canada, Quebec's Ministry of Sustainable Development, Environment and Climate Change and the Department of Forests, Wildlife and Parks Of Quebec - and Stratégies Saint-Laurent, a non-governmental organization active in riparian communities, share their expertise and efforts to report to the public on the status and long-term evolution of the St. Lawrence River.

For more information on the state of the St. Lawrence monitoring program, please visit our website: http://planstlaurent.qc.ca/en/state_monitoring.html

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